



## Does bilateral transverse cerebral venous sinus stenosis exist in patients without increased intracranial pressure?

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### ABSTRACT

**Objective:** Transverse cerebral venous sinus stenosis (TSS) is common among patients with idiopathic intracranial hypertension. TSS likely also exists among individuals with normal intracranial pressure (ICP) but the prevalence is unclear. The goal of this study was to identify patients with incidental TSS and normal ICP and describe their characteristics.

**Methods:** Among 240 adult patients who underwent brain magnetic resonance imaging (MRI) with magnetic resonance venography (MRV) with contrast at our institution between September 2009 and September 2011, 44 had isolated TSS without further substantial imaging abnormality. Medical records were reviewed for symptoms of increased ICP, papilledema, cerebrospinal fluid (CSF) constituents and opening pressure (OP), and reason for brain imaging. Of these, 37 were excluded for confirmed or possible idiopathic intracranial hypertension. Of the remainder, 5 had CSF-OP  $\leq 25$  cmH<sub>2</sub>O without papilledema, and 2 did not have measured ICP, but had no papilledema or symptoms of increased ICP. Imaging was re-interpreted to assess for signs suggestive of elevated ICP and to characterize the TSS further.

**Results:** All patients were women (mean age: 41, mean BMI: 37.1). CSF contents were normal, but OPs were at the upper limit of normal (22–25 cmH<sub>2</sub>O). Indications for MRI/MRV included query pituitary abnormality (1), migraine (4), and anomalous-appearing optic nerves (2). All had bilateral TSS. Six had short TSS and an empty sella; 1 had long TSS and no empty sella; 1 had flattening of the posterior sclera; 2 had prominence of peri-optic nerve CSF.

**Conclusion:** Asymptomatic bilateral TSS exists in patients with ICP  $\leq 25$  cmH<sub>2</sub>O, but is likely uncommon. CSF-OP was at the upper limit of normal in our patients, who also had other radiologic signs suggestive (but not specific) of chronically-raised ICP. Findings of bilateral TSS on imaging should prompt funduscopic examination for papilledema.

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### 1. Introduction

Consider the following real-life scenario: a 24-year-old obese woman presents to an optometrist for a routine eye examination. Funduscopic examination reveals anomalous elevated optic nerves concerning for bilateral disc edema. Brain magnetic resonance imaging (MRI) with head magnetic resonance venography (MRV) performed at an outside institution shows bilateral transverse sinus stenosis (TSS). There is no empty sella, no flattening of the posterior sclera, and no prominence of peri-optic nerve cerebrospinal fluid

(CSF). Because of concern for raised intracranial pressure (ICP), a lumbar puncture is performed and shows an opening pressure of 8 cmH<sub>2</sub>O with normal CSF constituents. She develops a severe low-pressure headache requiring a blood patch. Neuro-ophthalmologic examination confirms bilateral congenitally crowded discs with peripapillary atrophy but no true disc edema.

Recent advances in non-invasive cerebral vascular imaging such as MRV and computed tomography venography have shown that unilateral or bilateral TSS is common among patients with elevated ICP, particularly those with idiopathic intracranial hypertension (IIH) [1]. In addition, it is not uncommon for neuroradiologists to suggest a diagnosis of elevated ICP when reporting “incidentally found TSS” on routine brain imaging and to recommend “clinical correlation” or even a lumbar puncture to measure the CSF opening pressure (CSF-OP) in the patient. Although it is believed that TSS exists in the general population, and is not specific to elevated ICP,

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the prevalence of TSS among individuals with normal ICP is unclear. Our patient's history, along with our neuroradiologists' experience, led us to believe that bilateral TSS with normal ICP may not be unusual. The goal of our study was to identify patients with TSS and normal ICP and describe their characteristics.

## 2. Materials and methods

This study was approved by our Institutional Review Board. All patients who underwent standardized brain MRI and contrast-enhanced MRV at our institution between September 2009 and September 2011 were identified. All studies were reviewed prospectively to select patients with TSS but no cerebral venous thrombosis. Patients who had a normal MRV or any abnormality other than TSS were excluded. All TSS patients' medical records were retrospectively reviewed and all patients with definite IIH and those with insufficient clinical information were excluded. Age, race, gender, height and weight were recorded. The reason for the MRI, symptoms of increased ICP, and examination findings, including funduscopic examination, were recorded, as were CSF-OP, when available.

MR imaging was performed using a standardized protocol at either 3.0T (Siemens Trio, Erlangen, Germany) or 1.5T (Siemens Avanto, Erlangen, Germany or GE Signa, Milwaukee, Wisconsin) using a standard head coil. All patients underwent contrast-enhanced MRI along with contrast-enhanced MRV. The MRI/MRV protocol included routine pre-contrast axial diffusion-weighted, T1-weighted, T2-weighted gradient recalled echo (GRE), and sagittal T1-weighted images. An axial precontrast MRV mask was obtained (TR of 4–6 ms, TE of 1–2 ms, and flip angle of 22°–30° with slice thickness of 0.8–1.4 mm). A standard dose (0.1 mmol/kg) intravenous gadolinium based contrast agent (Multihance, Bracco Diagnostics Inc.) was administered at 2.0 cc/s, and the axial MRV sequence was repeated 60 s following contrast administration. Post-contrast axial T2-weighted and T1-weighted, and sagittal volumetric T1-weighted GRE images of the brain were then acquired. The pre-contrast MRV dataset was subtracted from the post-contrast dataset, and multiple oblique maximum intensity projections (MIPs) were generated from this subtracted dataset with rotation around the craniocaudal axis ("spin") or the transverse axis ("nod") at 6° increments.

All MRIs and MRVs were re-interpreted by an experienced neuroradiologist (AMS). Each patient's full set of images was evaluated for the following imaging findings: presence of empty sella, flattening of the posterior sclera, prominence of peri-optic nerve CSF and bone changes at the level of the stenosed sinus. MRV source data and MIP images were evaluated for location and extent of any dural venous sinus stenosis, according to the description of Farb et al. [1]. A combined conduit score (CCS) was calculated for each patient (Table 1). Only patients with TSS considered "typical of IIH" were included in this study. One patient had prominent arachnoid granulations in addition to TSS. None had any prior history of cerebral venous stenosis.

## 3. Results

Two hundred and forty consecutive patients underwent standardized brain MRI/MRV with contrast at our institution during the inclusion period. One hundred and ninety-six patients were excluded: 140 with normal MRV, 36 with venous sinus thrombosis, 14 with other intracranial abnormalities and 6 with venous sinus stenosis and additional parenchymal abnormalities. Medical records of the remaining 44 patients were reviewed for symptoms of increased ICP, evidence of papilledema, CSF constituents and opening pressure. Twenty-nine patients with definite

IIH diagnosed using the most recent diagnostic criteria [2] were excluded. Eight patients with incomplete clinical information in whom IIH was not definitively ruled out were also excluded.

The characteristics of the 7 remaining patients are summarized in Table 1 (the patient presented in the introduction did not have her MRV performed at our institution, and therefore was not included in our study). All patients were women (5 African-American, 2 Caucasian). The mean age was 41 years old (range 30–60). All were overweight or obese (mean BMI 37.1 kg/m<sup>2</sup>). One patient had obstructive sleep apnea, 1 had anemia and 5 had systemic hypertension. Five patients had episodic headaches consistent with migraine. None of the 7 patients had papilledema. Five of the 7 patients had a lumbar puncture in the lateral decubitus position. All 5 of these patients had normal CSF constituents and a CSF-OP of  $\leq 25$  cmH<sub>2</sub>O, but all had a CSF-OP that was at the upper limit of normal (22, 23, 24, 24, 25 cmH<sub>2</sub>O). The other 2 patients did not have a lumbar puncture performed, but neither had papilledema nor symptoms indicative of elevated ICP.

Indications for MRI/MRV were: a query of pituitary abnormality (1), migraine (4) and anomalous-appearing optic nerves (2). By definition, all patients had bilateral TSS (Table 1 and Figs. 1 and 2). In addition, 1 patient had three other radiologic signs suggestive of increased ICP (empty sella, flattening of the posterior sclera and prominence of peri-optic nerve CSF), 1 patient had both an empty sella and prominence of peri-optic nerve CSF and 4 patients had an empty sella. No patient had bone changes at the level of the stenosed sinus.

## 4. Discussion

Among 240 patients who had a high-quality contrast-enhanced MRV specifically looking for TSS performed at our institution over a two-year period, only 7 patients had isolated TSS without symptoms or signs of elevated ICP. Although this number is likely an underestimate because of our very strict inclusion criteria and the retrospective nature of our study, this suggests that normal ICP is unlikely to be found in patients with TSS. This is in concordance with prior studies which have evaluated this question from the opposite direction: that is, determining the frequency of normal MRVs among patients with possible IIH or for so-called "IIH without papilledema" [3,4]. Farb et al's [1] original MRV study demonstrated bilateral TSS in 27 of 29 patients with IIH and in only 4 of 59 controls, suggesting that bilateral TSS is highly suggestive of raised ICP in the correct clinical setting. However, although the authors mentioned that none of the controls was being evaluated for IIH and that they had no symptoms or signs of neurologic disease, the CSF-OPs were not provided and it is unclear whether these patients had funduscopic examinations looking for papilledema.

Although our patient described in the introduction with obvious bilateral TSS on MRV had a CSF-OP of only 8 cmH<sub>2</sub>O, all 5 patients included in our study who had a lumbar puncture performed had CSF-OPs that were at the upper limit of normal. None of these 5 patients had symptoms or signs of raised ICP, but they all had episodic headache suggestive of migraine. These observations raise the question as to whether the bilateral TSS observed in our patients (who do not have IIH) are truly incidental or might be somehow related to mildly elevated ICP responsible for migraine-like headaches. Interestingly, as previously described [5], other MRI findings commonly found in patients with chronically raised ICP [3,6,7] were present in most of our patients, including an empty sella in 6, prominence of the peri-optic nerve CSF in 2, and flattening of the posterior sclera in 1. A recent study [6] suggested that the presence of at least two radiologic signs suggestive of increased ICP (e.g., empty sella and TSS, or prominence of peri-optic nerve CSF and empty sella) is very suggestive of intracranial hypertension in

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